USAF Manufacturing Technology

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HIGHLIGHTS

Air Force Research Laboratory • Materials and Manufacturing Directorate • Manufacturing Technology Division
Wright-Patterson AFB, Ohio www.afrl.af.mil

Improved Manufacturing Process Reduces Cost of F-22 Components

Northrop Grumman Corporation, of Baltimore, MD, has developed an improved manufacturing process for F-22 aircraft radar components. The new process could result in a cost avoidance of nearly $87 million on the planned production run for the aircraft.

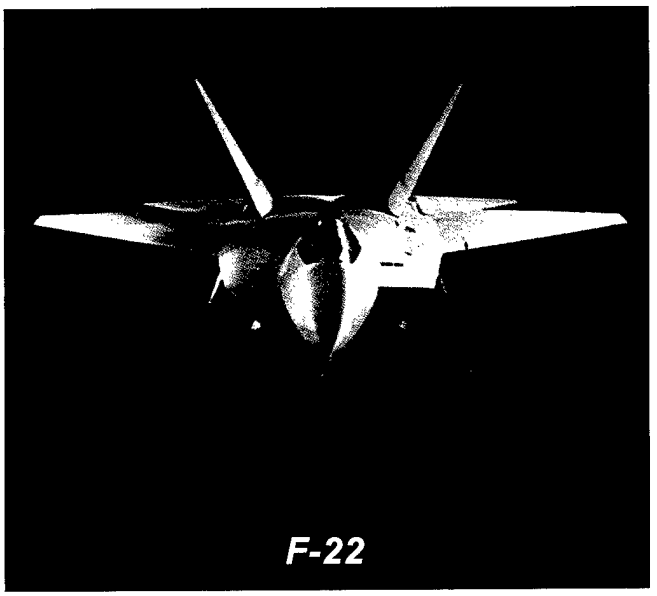
The process replaces thousands of costly and labor intensive flex circuit interconnects on the radar's subarray components with improved automated ribbon bonds. This reduces the amount of hands-on labor and rework required and increases the number of acceptable arrays per production run.

The F-22's APG-77 electronically scanned array antenna is composed of several thousand transmit/receive modules, circulators, radiators and manifolds assembled into subarrays and then integrated into a complete array. The baseline design used thousands of hand-soldered flex circuit interconnects to make the numerous radio frequency, digital, and direct current connections between the components and manifolds that make up the subarray.

By replacing the hand-soldered flex circuit interconnects with automated ribbon bond interconnects, the first pass yield of the subarray assembly has been vastly improved. Touch labor and rework have been simultaneously reduced. The ribbon bonding process completely eliminates eight different part numbers associated with the flex circuits and can be readily reprogrammed in response to changes in subarray design.

Under this contract with the Air Force Research Laboratory Materials and Manufacturing Directorate's Manufacturing Technology (ManTech) Division, Northrop Grumman Corporation improved the ribbon bond interconnect process currently used in the assembly of radar circulators and applied it to the assembly of the entire radar subarray. They used design of experiments techniques to achieve reliable bonds on six different materials, at relatively low working temperatures. The need for low working temperatures was driven by the fact that while ribbon bonds are typically formed at 160 degrees Celsius, the adhesive that mounts some components on the radar subarray can tolerate no more than 100 degrees Celsius.

The process was scaled up to allow all of the electrical interconnects of a relatively large assembly, the radar subarray, to be formed in one automated process. The new processes allow reliable, repeatable ribbon bonds to be formed at low working temperatures. These can be incorporated into an automated assembly work cell which is capable of assembling a



F-22

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Inside

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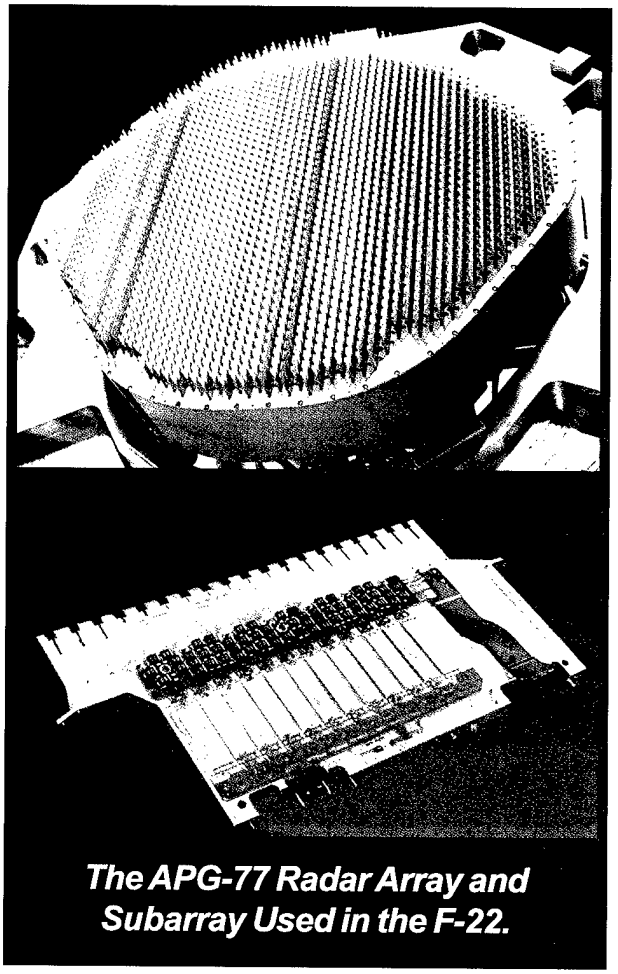
Over the planned production run of F-22 Raptors, this will result in a total cost avoidance of $60 to $87 million.

full-size subarray in a production mode. This working cell includes the plasma cleaner for ribbon bonding along with robotics and reflow ovens for other F-22 subassembly fabrication.

Before the process improvement, APG-77 radar subarrays averaged more than three defects requiring rework per subarray. With the new interconnect process, defects requiring rework have been reduced to less than one defect per eight subarrays, and the process for reworking a defective ribbon bond is much simpler. The process capability for the interconnect process improved from .86 for the flex circuit, to at least 1.33 for the ribbon bond interconnect.

This ManTech program automated the process for making the radio frequency, digital, and direct current electrical connections between the components and manifolds that make up an F-22 radar antenna subarray. By replacing costly and labor intensive flex circuit interconnects with automated ribbon bond interconnects, this program resulted in a cost avoidance of $98,000 in material due to the elimination of flex circuits, and $157,000 in first cycle and rework labor. Over the planned production run of F-22 Raptors, this will result in a total cost avoidance of $60 to $87 million. This interconnect process has been selected by the F-22 Program Office for production F-22 radar systems.

For more information, contact the ManTech Technology Information Center at techinfo@wpafb.af.mil or (937) 256-0194 Refer to item 00-121



The APG-77 Radar Array and Subarray Used in the F-22.

High Resolution Real-Time Radioscopy

Improves Aircraft Inspections, Lowers Costs

Lockheed Martin Missiles and Space Advanced Technology Center is using high-resolution real-time radioscopy (HRRTR) systems to improve x-ray inspections of aircraft components.

Developed under a contract with the Air Force Research Laboratory's Materials and Manufacturing Directorate's Manufacturing Technology (ManTech) Division, the systems use a high-resolution capability and are based on solid-state sensing devices. They enhance performance, reliability, defect sensitivity and cost effectiveness over conventional film-based and image intensifier-based real-time radioscopy (RTR) x-ray inspection procedures.

Radioscopy inspection is used to locate hidden defects in aircraft structures such as cracking, corrosion and foreign objects. It's also used extensively in the manufacture of aircraft turbine engine components to detect and evaluate shrinkage cavities, micro-shrinkage, porosity, inclusions and cracking. Prior to the development and application of HRRTR, real-time radioscopy based on vacuum tube technology such as isocon tube television cameras and image intensifiers was a widely used capability, and replaced film-based radiography in many applications.

Such RTR systems have significant advantages for certain types of inspections, particularly since the images are provided at video frame rates, which enables the inspection of large areas faster and cheaper than with conventional radiographic film. Vacuum tube-based RTR has significant limitations when compared to film-based radiography, the most critical of which is lower spatial resolution and reduced contrast sensitivity. Vacuum tube-based systems also have limited dynamic range and often, gross image distortion. Another limitation is that the size, weight and fragility of RTR systems are such that practical field-level inspections are usually not feasible.

Recognition of these limitations led to the formulation of HRRTR research and development programs. This project developed three complete Radiographic Imaging Systems. The initial system, HRRTR-1, was fully integrated with a manipulator and microfocus x-ray source. Two additional systems, HRRTR-2 and HRRTR-3, were camera and computer only designs that were used to upgrade the inspection capabilities for existing x-ray facilities at the Ogden and Oklahoma City Air Logistics Centers. The primary goal of the program was to design and develop HRRTR capability based on solid-state sensing devices and in the process, achieve a major advance over film-based and image intensifier-based RTR x-ray inspection procedures in terms of system performance, reliability, defect sensitivity and cost effectiveness.

The new solid state HRRTR technology transfers images from an x-ray to a visible light scintillator to the charge-coupled device (CCD) sensor via a fiber optic or lens-based optical coupling. The fiber optic approach provides a significant increase in efficiency over lenses, at the cost of limiting the effective field of view. This approach was selected for its potential to meet the needs for x-ray imaging systems

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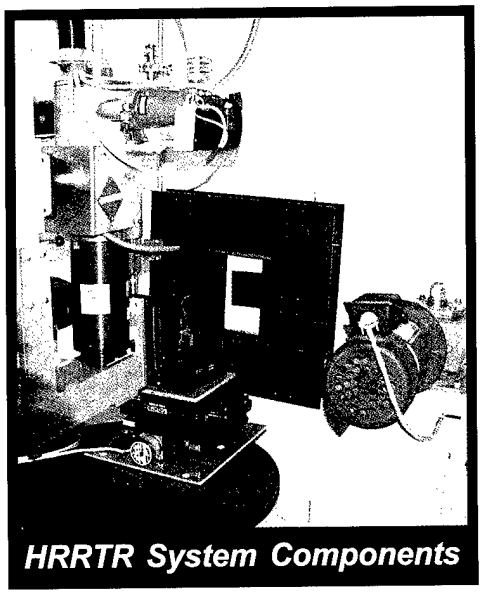

HRRTR System Components

...HRRTR system significantly reduces the need for photographic chemicals and X-ray film, while saving millions of dollars...

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with resolutions comparable to film radiography, but with dynamic ranges and contrast sensitivities better than film. The resulting x-ray imaging systems have resolutions significantly better than vacuum tube based RTR systems, such as enhanced dynamic range and contrast sensitivity and reduced image distortion.

HRRTR is currently being used in the F-22 program, for mortar munitions quality verification at the Army's Milan, Tenn., plant and to inspect fuel tank welds for Lockheed Martin Aeronautics. HRRTR technology is also being evaluated for possible use in other Lockheed Martin government programs such as the external tank for the space shuttle, NASA's X-33 program, and airframe and engine component inspections in the Air Force's Joint Strike Fighter program.

HRRTR technology provides aircraft maintenance personnel with highly improved, less expensive, nondestructive inspection tools for evaluating corrosion, foreign object damage and severe fatigue damage in airframes and engine components. Replacing conventional film-based and image intensifier-based RTR inspection procedures with an HRRTR system significantly reduces the need for photographic chemicals and x-ray film, while saving several million dollars in nondestructive inspection costs. Use of the HRRTR system has decreased image processing time, decreased readout time, and improved resolution.

HRRTR Computer Station

For more information, contact the ManTech Technology Information Center at techinfo@wpafb.af.mil or (937) 256-0194 Refer to item 99-457

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Adaptive Process Control Technology

Improves Quality Of Semiconductor Materials

AIWare Incorporated has developed a real-time monitoring system that improves the quality of semiconductor materials used in Air Force defensive radar systems while reducing their production costs.

Their process control system automatically adjusts the manufacturing process to affect the desired thickness and chemical makeup of multi-layer semiconductor materials. The system was developed under a contract with the Air Force Research Laboratory Materials and Manufacturing Directorate's Manufacturing Technology (ManTech) Division.

Process controls are one of the key elements of building quality into an advanced semiconductor material. Built-in quality reduces inspection, rework and scrap costs, while increasing yield in lower overall acquisition costs. The control of advanced semiconductor processes to date has been limited because deposition processes for advanced semiconductors exceed the limits of conventional control technology.

The prototype system devised in this Small Business Innovation Research contract overcomes the response time limitations of conventional approaches. The system adaptivity is based upon a unique coupling of neural networks and genetic algorithms to distinguish process information from background noise for precise control of material thicknesses, within three atomic layers. Using a genetic algorithm to continually search and denote the process trajectory, the control system is able to precisely predict material thicknesses a few time steps into the future, which allows for automatic in-process thickness control.

Relating to material processing, detection of communication faults and subsequent corrective actions are limited by time constants which sometimes preclude real-time control. But the coupling of neural networks and genetic algorithms has proven useful in capturing the process trajectory of a fault. Once a trajectory pattern is learned, corrective actions can be applied in real-time, in some cases alleviating the fault altogether, or at a point where it can be resolved with minimal or no performance degradation or cost.

This project developed the technology for the integrated use of neural networks and genetic algorithms for real-time process control in producing semiconductor materials. This will reduce development and production costs of advanced semiconductor materials for Air Force threat and detection applications. In addition, the novel architecture and unique capabilities afforded by this process control technology have demonstrated applications in real-time fault detection of internet data communication routes. Because of the internet application and that market's size, AIWare is discussing the sale of their technology to Computer Associates Inc., who would market it for those applications.

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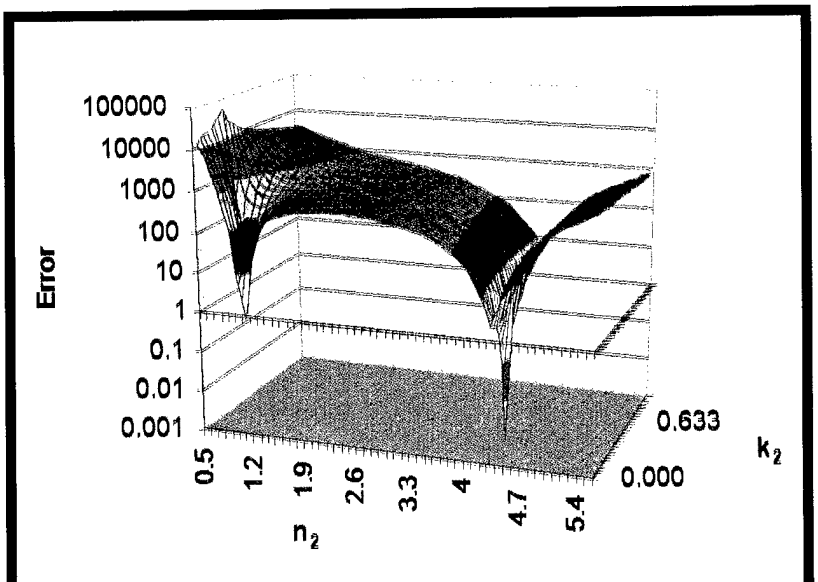


Global Minimum Optimization

Physics of Failure Approach

Lowers Life Cycle Costs of Aircraft

"PASES is a pioneering shift which will substantially lower the life cycle cost of aircraft..."

Under a contract with the University of Maryland, the Air Force Research Laboratory Materials and Manufacturing Directorate has initiated a program that will substantially lower aircraft life cycle costs.

The Physics of Failure Approach to Sustainable Electronic Systems (PASES) project establishes the causes of failure during the design stage, and changes the maintenance focus to a proactive approach of preventing failures.

"This is a radical change in the way we manage sustainability," said Brian Moore, program manager for the PASES project.

The change came about as a result of a 1994 memo from Dr. William Perry, then Secretary of Defense, instructing officials to write procurement specifications in terms of performance requirements. In response to this directive, the military stopped supporting military specifications and turned the onus over to suppliers to design and deliver equipment that meets performance specifications. One of the most important of these performance specifications is equipment reliability.

Traditionally, equipment reliability has been defined in terms of Mean Time Between Failure (MTBF). This measure is simply the number of equipment operating hours accrued by the fleet in a given time period divided by the number of failures that occurred during that same time period. While the sequence of MTBF numbers calculated over a long period is a useful historical record of the reliability of a piece of equipment, it is not of much help to mission and logistics planners who need to know how long a specific piece of equipment will last. That knowledge enables planners to forecast the times at which failure will occur and permits maintenance activities to be planned so that unscheduled maintenance activities are avoided.

The idea of maintaining equipment only at scheduled times leads to the notion of a Maintenance Free Operating Period (MFOP). An MFOP is a period of time during which a system is both operational and is able to carry out its required functions without maintenance activities and without encountering failures.

"The use of an MFOP provides the ability to plan for a period of maintenance in advance," Moore explained. "It permits an optimized cost model to be developed, enhancing the application effectiveness and operational availability of a system."

Moving from using MTBF to MFOP as a measure of reliability is an approach under development by the Air Force Research Laboratory Materials and Manufacturing Directorate Manufacturing Technology (ManTech) Division. Based on work done at the Computer Aided Life Cycle Engineering (CALCE) Electronic Products and Systems Center (ESPC), at the University of Maryland, the PASES program is attempting to predict failure occurrence during the design cycle.

"The old idea of MTBF led to the mindset that random failures are an unavoidable fact of life," Moore said. "But most failures can be traced back to a root cause, and knowledge of this enables designers to design the cause out of the equipment or predict the time to failure. This is the aim of this program."

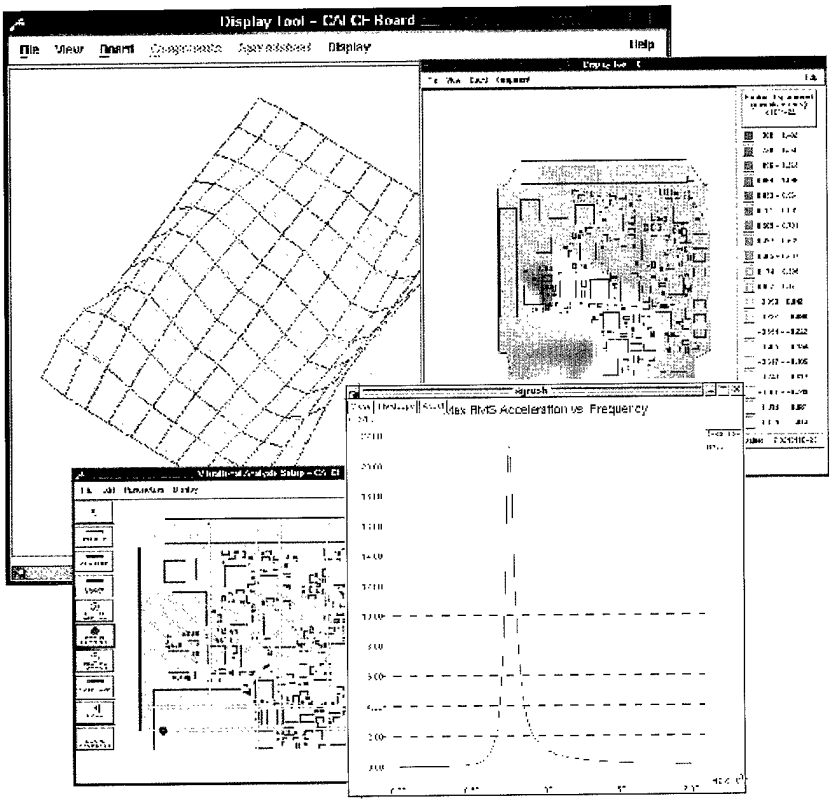
This program focuses on the creation of systems for the defense industry that have lower life cycle sustainment costs by instituting a cradle-to-grave Physics of Failure (PoF) program as an up-front, proactive and concurrent approach to achieving system reliability, manufacturability, technology and parts risk management and affordability. Computer software which models a whole range of failure mechanisms and predicts the time to failure of each one has been developed by CALCE for use by equipment designers. This software, called calcePWA, is being provided free to Air Force contractors to work concurrently with

the design process to facilitate proactive PoF design assessment of electronics. The software provides the capability to model most modern printed wiring assemblies (PWAs) and contains a state of the art reliability assessment capability developed around product life cycle analysis.

The software gives designers the capability to calculate an MFOP and assess whether the aircraft will be able to complete the mission, while providing the end user with a maintenance schedule to restore the equipment to a state which guarantees the success of the next mission. The PASES program also manages the electronic component selection, ensuring only high quality, reliable components are selected by the equipment supplier. The component management element tracks the obsolescence status of each component so that corrective actions can be taken in time to avoid equipment being put out of service due to lack of spare parts.

"The calcePWA software has been successfully applied to electronic systems in avionics, automotive, computer, consumer, military, space, and telecommunication applications," Moore concluded. "It has been validated against test data as well as accepted numerical solutions. PASES is a pioneering shift which will substantially lower the life cycle cost of aircraft by establishing the causes of failure during the design stage."

For more information, contact the ManTech Technology Information Center at techinfo@wpafb.af.mil or (937) 256-0194 Refer to item 00-145



Screen Shot of the calcePWA Software

Air Force Hosts Defense Priorities

And Allocations System Training Conference

"It (DPAS) allows us to make a higher priority request of a manufacturer or supplier in order to meet the needs of national defense."

Representatives from several Department of Defense (DoD) agencies gathered in Indianapolis recently, for the Defense Priorities and Allocations System (DPAS) 2000 Training Conference.

There, nearly a hundred key DPAS representatives from the Army, Navy, Air Force, Defense Logistics Agency and the Defense Contract Management Agency spoke with speakers and panelists to learn more about the Priorities and Allocations System.

The mission of the DPAS is to assure the timely availability of materials, facilities and services to support the armed forces and our allies during both peacetime and contingencies, by requiring preferential contract performance. Under DPAS, Special Priorities Assistance is used to expedite delivery of critical defense items ranging from munitions to global positioning systems.

"This Special Priorities Assistance was used during Desert Storm, Desert Shield, Operation Joint Endeavor and Operation Allied Force," said James Neely, the Air Force Materiel Command DPAS program manager. "It allows us to make a higher priority request of a manufacturer or supplier in order to meet the needs of national defense."

DPAS is a feature of Title I of the Defense Production Act, and as such, represents law. Executive orders delegate authority to carry out the provisions of DPAS to the Department of Commerce. Within this department, the Office of the Strategic Industries and Economic Security is responsible for administering DPAS.

Neely provides oversight for the statutory provisions of the DPAS for AFMC and provides Special Priorities Assistance in support of urgently needed material when the problem can not be resolved at the field activity level. "Following the provisions of the DPAS is a legal requirement for everyone who receives contracts or orders that have a priority rating under the DPAS," Neely explained. "So it just makes good business sense to be familiar with the system."

Confronted with considerable reorganization and personnel turnover across Air Force and other DoD agencies, the Office of the Deputy Under Secretary of Defense asked the Air Force to host this much-needed DPAS Training Conference. Prior to the main conference, Neely and Rick Meyers, of the Department of Commerce, provided a DPAS Tutorial for newly assigned focal points. "The conference met all of our training goals and also opened the door for future conferences," Neely remarked.

British and Canadian defense representatives also attended the conference, where a major focus area described international efforts to assure Security of Supply. A featured speaker, Steve McCarthy, Defence Supply Attache at the British Embassy, spoke on Security of Supply from a European Perspective. He underscored the importance of the topic by quoting Prime Minister Tony Blair saying, "We are all internationalists now, whether we like it or not. We cannot refuse to participate in global markets if we want to prosper...on the eve of a new millennium we are now in a new world. We need new rules for international cooperation and new ways of organizing our international institutions." McCarthy also introduced the recently signed United Kingdom-United States "Declaration of Principles" supporting security of supply in meeting national defense requirements.

Gary Powell, of the Office of the Deputy Under Secretary of Defense, indicated, "The DoD recognizes that the national security environment is changing. This new environment will require partnerships in Security of Supply relations with our allies."

John Boyle, of Canada's Public Works and Government Services, echoed these sentiments and emphasized Canada's participation in DPAS, highlighting the long-standing Memorandum of Understanding supporting DPAS between the United States and Canada.

The Industry Keynote Speaker for the conference was Charles H. Davis III, of Boeing, who spoke on the "Joint Direct Attack Munition (JDAM) — The Kosovo Experience and DPAS." During this presentation of the effec-

tiveness of the JDAM system in Operation Allied Force, Davis indicated that schedule acceleration drove JDAM's necessity to pursue Special Priorities Assistance through DPAS. With this assistance, JDAM was able to triple production rates to meet the warfighter's needs.

Other key industry speakers included Dr. Dean Johnson, of Honeywell, and James Muehleisen, of Motorola. A special DoD award for demonstrated excellence in implementing the DPAS program was presented to Wayne Easter and Dan Dolan from Defense Contract Management Center, Phoenix. Several major suppliers under the cognizance of DCMC-Phoenix were experiencing high delinquency rates which were due primarily to improper implementation of DPAS at their production facilities. DCMC Phoenix, in cooperation with the supplier, undertook extensive training efforts to make sure all were aware of the legal requirements under DPAS, and developed improvements, plans and shared lessons learned.

For more information, contact the ManTech Technology Information Center at techinfo@wpafb.af.mil or (937) 256-0194

Multi-Junction Design Increases Power, Reduces Cost of Space Solar Cells

...the U.S. is world dominant in high performance solar cell technology for space...

A recent Air Force Manufacturing Technology program has reduced the cost and increased the power of space solar cells, setting the industry standard and giving the U.S. world dominance in this technology.

Under a contract with the Air Force Research Laboratory (AFRL) Materials and Manufacturing Directorate (ML), and under technical direction by the AFRL Space Vehicles Directorate (VS), TECSTAR Incorporated and SpectroLab Incorporated developed multi-junction space solar cells with solar to electric conversion efficiencies of 25 percent. The three-junction solar cell design converts a larger portion of the solar spectrum into electricity than previous designs, providing a 35 percent increase in available power for the same area of solar panel, and reducing the cost per watt by 15-20 percent.

High performance solar cells are required to provide added power for space missions without enlarging the solar arrays, which would result in the need for a larger launch vehicle due to increases in mass and volume. Prior to this program, multi-junction solar cells were laboratory curiosities that were too expensive for general use. This program, managed by ML's Manufacturing Technology (ManTech) Division, was initiated to bring the cost of this technology down to the point that it could be beneficially used on operational spacecraft.

The cooperative program was funded by ManTech, VS's Space Technology Integration and Demonstration Division, the Space and Missile System Center, and the National Aeronautics and Space Administration, and grew out of the experience and expertise developed over 15 years of high-efficiency solar cell development conducted at AFRL. Previous state-of-the-practice space solar cells were single-junction gallium arsenide with efficiencies of 18.5 percent. Multi-junction (MJ) solar cells for spacecraft applications became the industry standard as the result of this program. The three-junction design built upon AFRL's development of the world's first commercially available large-area 16 percent efficient gallium arsenide (GaAs) solar cell in 1984, and 18.5 percent efficient GaAs/germanium (GaAs/Ge) solar cell in 1989.

The new solar cells are a direct replacement for existing cells, so that the same substrate panels and deployment mechanisms can be used and the mass per unit area is unchanged. Unlike previous programs for single-junction cells, this program provided explicit cost objectives, namely limiting the production cost increase to 15 percent per solar cell. When combined with the 35 percent increase in cell efficiency, this results in a 15 percent reduction in cost per watt of solar cells.

The resulting technology transfer process was direct and immediate within each company. Spectrolab, Inc., of Sylmar, CA, and TECSTAR, Inc., of City of Industry, CA, sought to develop and market the most advanced, cost-effective solar cell technology for the next-generation of spacecraft. Today, both companies commercially offer the three-junction solar cells with efficiencies of 24.5-25 percent. The new MJ cells can enable both increased payload power while reducing solar array size and mass to allow increased payload mass. This technology is now available to all domestic spacecraft prime contractors for use on both commercial and government programs.

U.S. government space programs are the early beneficiaries of this technology, since it allows more capable spacecraft to be built around existing buses and launched on existing boosters. Within the next few years, it's expected that almost all new or block upgrade military spacecraft will use this technology, and within the next five years, at least a dozen military spacecraft will be launched that use the MJ solar cells. Many commercial communications satellites already use this technology to provide more transponders per spacecraft, thus reducing the lifecycle cost and therefore the price to the consumer.

The majority of the estimated 800 commercial and military systems over the next five years are expected to use MJ solar cell technology. More capable surveillance missions provided at lower cost will benefit both the military as well as the civil sector in missions such as environmental monitoring. The project will also result in lower consumer cost for telecommunications, internet, television broadcast and other services. These lower costs allow U.S. industry to be more competitive in the global marketplace for these services.

As a result of the ManTech for Multi-Bandgap Solar Cells Program, the U.S. is world dominant in high performance solar cell technology for space, with foreign companies not expected to manufacture these products for at least five years. This program resulted in increased payload mass, reduced cost, and complete market penetration of multi-junction solar cell technology. Hughes Space and Communications Company's HS 601 and HS02 spacecraft use this technology exclusively and other prime contractors use it for their high performance spacecraft.

The success of the program has completely eliminated the prior single junction gallium arsenide technology, and new relationships from MJ solar cell development have led to the design of a new 35-40 percent efficient four-junction solar cell. A program is currently underway to develop this 35-40 percent solar cell.

For more information, contact the ManTech Technology Information Center at techinfo@wpafb.af.mil or (937) 256-0194 Refer to item 98-079

Weapon System Integrated Cost Estimating Model

Saves Time and Resources in Decision Making Analyses

...reduces the time required for weapon system cost estimates from days or even months to hours or less

A project managed by the Air Force Research Laboratory's Materials and Manufacturing Directorate (ML) has produced an integrated computer tool which helps decision makers determine the cost and return on investment for technology development options.

Analysts at Frontier Technology Inc. (FTI), in a contract with ML, have developed a computerized cost-estimating system that reduces the time required for weapon system cost estimates from days or even months to hours or less. The tool enables selection of the best value by integrating cost models and weapons system operations and support data.

Concepts and technologies for military systems have historically been evaluated based primarily on performance. Now, Air Force leaders emphasize *affordable* systems and technologies for either increasing performance, reducing costs, or for extending the operational life of a system. This need for more affordable systems requires a set of computer tools that can reliably assess life cycle cost and affordability for a system before funding priorities are assigned by the weapon system technology-development manager.

In response to this increasing need, FTI, under a Small Business Innovation Research project with ML's Manufacturing Technology (ManTech) Division, developed the Integrated Desktop Analysis and Planning System (IDAPS) Cost Estimation (ICE™) Tool. This unique tool is a flexible system of automated cost analysis models, tools, and data, which enable users to estimate in minutes the cost and return on investment of advanced program concepts. The ICE™ Tool accomplishes this by estimating life cycle cost, as well as system operating and support cost savings. The flexible tool enables the user to integrate new models, analysis techniques, and data sources, to estimate affordability and to examine various design and cost trade-offs.

The ICE™ Tool uses a top-level, work breakdown structure to specify the detail characteristics of a new system concept or

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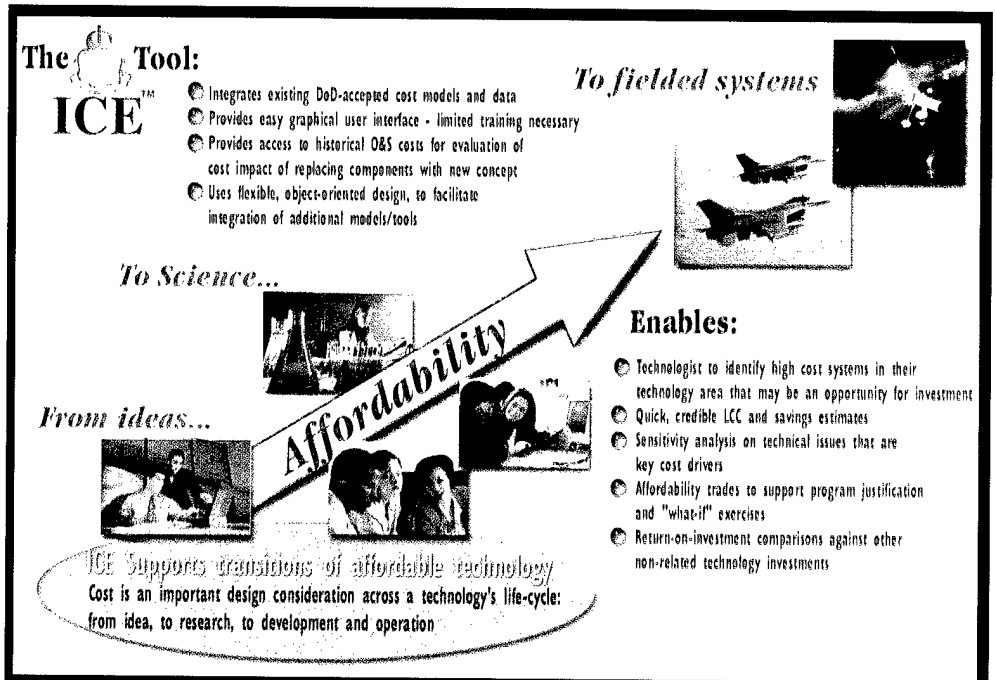

The ICE™ Tool helps prioritize technology choices

Precision High-Speed Machining System

Reduces Cost and Weight of Aerospace Structures

An Air Force Research Laboratory Materials and Manufacturing Directorate (ML) effort has produced a precision high-speed machining with vibration control system.

The system will help the machine tool industry's ability to produce aluminum aerospace structures. It will also reduce their cost and weight.

In the high-speed machining world, there is a need for a high-speed, high-feed-rate, precision milling capability to produce extremely flexible aluminum aerospace structures. These components must have superior quality, minimum weight, and reduced part cost. Current technology is limited by several speed and vibration factors that keep high-speed machines from reaching their maximum metal removal rates.

Metal removal rates of these high-speed machines are limited by: 1) vibration, leading to damaged part surfaces; 2) low feed rates and accelerations leading to excessive slow down and time spent in cornering; and 3) limited path accuracy at higher feed rates resulting in errors. This program attempted to design, develop, and demonstrate a very agile and dynamically stable high-speed, high-feed-rate, 5-axis machine tool for producing extremely flexible aluminum aerospace structures with superior quality, minimum weight, and reduced part cost.

Under this contract, the Boeing Company, of St. Louis, Mo., assembled a team to tackle this task. Their team included Ingersoll Milling Machine Company, of Rockford, IL; Setco, of Cincinnati, OH; General Dynamics-Advanced Technology Systems (GD-ATS), of Arlington, VA; Manufacturing Laboratories, Inc. (MLI), of Gainesville, FL; and the University of Florida. The team established the performance requirements of the machine tool and designed and developed its vibration control technologies. They also fabricated and assembled the machine tool and demonstrated its capabilities.

Boeing used its experience in designing high-speed machined aircraft parts to drive the specific requirements of the machine tool. Ingersoll designed and manufactured a 5-axis, 1200 inch-per-minute feed-rate machine tool. Setco designed and fabricated the 36,000 revolution-per-minute spindle to allow active spindle vibration control. GD-ATS developed an active spindle vibration control system to dampen out vibrations in the spindle shaft. MLI provided the chatter recognition and control system. They also developed the feed forward control system to maximize path accuracy at high feed rates and accelerations.

This 60-horsepower high-speed spindle travels 60 inches in the "X" direction, 40 inches in the "Y" direction, and 20 inches in the "Z" direction. The University of Florida's Machine Tool Research Center provided a test bed for evaluating the component technologies developed under this project. The machine tool was installed in Boeing's St. Louis Advanced Manufacturing Technology facility for the demonstration.

This project improved the state-of-the-art in high speed machining, machine design, open architecture controls and linear motor technologies. The machine will continue to be used to determine and address the issues that will shape the future in these areas. Several of the ideas developed here have already started to seep into other machine designs.

This precision system will benefit the machine tool industry by allowing the production of extremely flexible, lightweight, high quality, aluminum aerospace structures at low cost. It will allow evaluation of leading edge vibration control and path accuracy, helping determine which technologies should be specified in future machine tool procurements. This will subsequently provide an increased capability to produce lightweight aerospace structures at an affordable cost.

This precision system will benefit the machine tool industry by allowing the production of extremely flexible, lightweight, high quality, aluminum aerospace structures at low cost.

For more information, contact the ManTech Technology Information Center at techinfo@wpafb.af.mil or (937) 256-0194 Refer to item 00-161

End of Contract Forecast

August 2000	Combat Survivor Evader Locator (CSEL) Module Improvement Process F33615-99-C-5508	Alliant Techsystems Incorporated
August 2000	Development of a Composite Material Selection Advisor (CoMaSa) F33615-99-C-5703	Florida International University Miami, FL
August 2000	Rapid Coater for Laser Shock Peening F33615-98-C-5116	LSP Technologies Incorporated Dublin, OH
August 2000	Parts Obsolescence Management Tool for Out Production Parts F33615-98-C-5129	TRW Incorporated San Diego, CA
August 2000	Computer Enhanced Eddy Current Detection F33615-98-C-5154	American Research Corporation Radford, VA
August 2000	Optimal Pre-Stressing Surfaces by Superfinish Hard Turning for Maximum Fatigue Life Multiple Contracts	Purdue University West Lafayette, IN
August 2000	Robust Scheduling and Diagnostics Using Simulation-Based Optimization Multiple Contracts	Georgia Institute of Technology Atlanta, GA
August 2000	Light Detection And Ranging (LIDAR) Wind Sensor Manufacturability F33615-97-C-5145	Coherent Technologies Incorporated Charleston, SC
September 2000	Advanced Manufacturing Technology Feasibility Demonstration 1 F33615-96-D-5119	Universal Technology Corporation Dayton, OH
October 2000	X-Ray Sensors for Real Time Control of Thin Film Deposition F33615-99-C-5702	Technology Assessment & Transfer Incorporated Dayton, OH

(Continued from page 12)

technology at the appropriate system level. This enables the user to define a new technology concept in as much detail as necessary to examine the cost sensitivities of various design options and to examine the concept's application to an existing weapon system. This is accomplished with the use of "wizards" that provide an easy-to-use, structured approach to define the technology concept and to describe its functional parameters.

All models and data elements operate in a "seamless," end-to-end process to input the parameters specified by the user into the models, to execute the models to calculate concept costs and to compare and evaluate the concept's return on investment. The cost results are then transferred into Microsoft Excel, Word, or text file formats. Graphs in Excel are generated to illustrate the cost savings and to show the estimated cost impact and return on investment of the technology concept. Operations and support cost values are expressed in the cost categories favored by the DoD Cost Analysis Improvement Group.

The ICE™ Tool was used for analysis on large air frame systems, and it accomplished the analysis that previously took two weeks, in less than five minutes. Similarly, sustainment analysts in AFRL used the tool to help find more affordable aircraft components and found it reduced the research time required for high-cost-to-maintain components by 97 percent.

This ManTech project produced the ICE™ Tool, which has saved up to 90 percent of the time and reduced the number of people required from several to just one in providing an effective cost-analysis capability. The tool enables the analyst to include cost as an important consideration during design trades, thus ensuring new technologies are affordable. In addition, with it's ability to show in minutes the cost savings of one technology choice compared to another, decision-makers can focus efforts and resources on the "best value" choices in their search for better performance at affordable lifecycle costs. The technology developed in this tool is being transferred through a commercial product that will be licensed by FTI.

For more information, contact the ManTech Technology Information Center at techinfo@wpafb.af.mil or (937) 256-0194 Refer to item 99-138

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Summer 2000

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